Engineering Aspects of Farm Operating Efficiency 1/

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The farm has often been compared with a factory. It is operated for the production of livestock, food, and raw materials for use in industry. The soil, buildings, machinery, and livestock make up the plant to correspond to the buildings, machines, and equipment of a plant for the manufacture of shoes or other article. Labor of course is involved in the farm factory, in the same way in which it is involved in a shoe factory. The crops to be grown, the selection and sale of the products, do not come within the field of the engineer. On the other hand, the equipment and the labor used are engineering matters and within the province of agricultural engineers.

To be efficiently operated, the farm factory as well as a shoe factory must be so organized, equipped, and coordinated that each one of the separate parts fits into the production program and is coordinated with all of the other parts. No factory can long stay out of bankruptcy which provides more power than is needed, which has one machine with twice the capacity of the next machine in the production line, or which has machinery and equipment not adapted to the kind of products which are to be manufactured. A superficial investigation of any farm will probably discover a number of maladjustments between the various engineering elements of the farm business or between one or more of these engineering elements and the farm business as a whole. Under any kind of an agricultural production program it is the efficient farmer who will survive and it seems to be the field of the agricultural engineer not only to design the machines and equipment to be used but to coordinate them for the purpose of securing efficiency in farm operation.

In 1929 the Bureau of Agricultural Engineering instituted a research project for determining the engineering needs of typical farms in the various States and the benefits which would result from the adoption of the indicated improvements. Since all suggested improvements would be financed by the landowners, it was necessary that the farms selected be those whose owners were progressive minded, who were financially able to make the recommended improvements, and who were keeping farm accounts, this last requirement being necessary because it is from these farm accounts that the benefits of the improvements, when and as made, will be determined. These limitations confined the cooperating farms to the better class of farms in each community. In fact, each farm is generally recognized as being one of the best in its locality. To date 107 of these farms in Georgia, North Carolina, South Carolina, Virginia, Michigan, Minnesota, and Ohio have been studied and the scope of the project is being extended as funds become available.

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Early in the investigation it developed that an engineering development program depended entirely upon the agricultural program and that it was impossible to plan a long-time engineering program on a farm without, at the same time, planning the cropping system and the livestock production to be carried on during this time. In spite of the fact that all of these farms are among the leaders in their respective communities, it was evident even to an engineer that the agricultural phases of the farm program were far from the best and it therefore became necessary to call in the assistance of the farm management authorities in each State for the purpose of working out a coordinated program in which each element of the farm business - the crops, livestock, buildings, equipment, soils, and the shape and condition of the fields - were all taken into consideration, each element in the completed plan being in the proper ratio to each other element and to the farm business as a whole.

In developing these farm programs primary consideration is given to the personal equation of the owner for of course the crops to be produced must be such that he likes to handle and that he knows how to raise. In fact, the farmer himself is probably the most important member of the planning unit because of his intimate knowledge of the farm and since any plan, to be successful, must be within his capabilities. As might be expected, the 107 farms studied covered a wide variation in size, type of farming, and soil and climatic conditions, as well as in crops produced and equipment used. There was not one of the farms which did not require a number of different engineering adjustments in order to promote efficiency. These adjustments were not expensive, most of them calling for the expenditure of very little capital and a number of them being of the kind that could be done largely with farm labor. A number of striking maladjustments between various elements of the farm business were brought to light as, for instance, a farm in southeastern Virginia having about 20 acres in cultivation and relying for its main income on a half dozen cows and a few chickens, had no other power on the place than a tractor. Another farmer had a complete outfit of power machinery, including a three-row general purpose tractor outfit and a ten-foot combine on a farm with 260 acres of cultivated land, 60 acres of which were in small grain, and with no field on the farm more than 4-1/2 acres in size. This latter case is a striking example of the lack of coordination between engineering elements of the farm business since the size of the fields was determined by open lateral drains which cut the fields up into such small units that the economical operation of equipment was impossible. Incidentally, the substitution of tile drains for the open lateral ditches not only eliminated the cost of annually clearing the open ditches, but added 10 per cent to the cultivated area of the farm. The income from this additional 10 per cent of area, with no increase in overhead costs, will be nearly all profit, and at the same time operating costs on the remaining 90 per cent will be markedly

reduced. Another example of a different type is a farm, largely in apple orchards, which had been leased out at a nominal rental by the owner on account of the difficulty of securing labor for orchard maintenance. The installation of a stationary spray outfit so reduced the amount of labor required that the owner now operates the orchard himself with a considerable gain in income. In this case, a single engineering improvement changed the entire plan of operation for the better.

While it has been impossible on each of these farms to indicate various engineering improvements which, in conjunction with the revised agricultural program, will result in increased net income, the studies so far have brought to light some rather fundamental considerations as to the effect of the various engineering elements of the farm business upon the farm business as a whole. For instance, in the Southeastern States, particularly, and in other States to some lesser degree, the farm surveys brought out the fact that many farms have too many fields, irregularly shaped and varying in size. For instance, the average number of fields per farm in the 20 farms studied in Georgia was 28.4. One farm had 74 fields which averaged 2-1/2 acres in size. A considerable number of these farms had from 20 to 30 fields averaging 4 to 7 acres per field.

For many years past agricultural authorities have been trying to establish on Southeastern farms a systematic soil building crop rotation but without success, as evidenced by the fact that not one of these 20 farms, each one being among the best in its locality, was following a balanced rotation system. It is obviously physically impossible with so large a number of fields of varying sizes to carry out any farming program which alternates the crops to be produced between the various fields in such a way as to build up soil fertility and, at the same time, produce each year approximately equal amounts of various crops. The plans as developed under this project have cut the number of fields down to a minimum, approaching the number of crops in the rotation program. The expense of reducing the number of fields has been small, involving usually the substitution of broad-based terraces for steep, narrow ones, the removal of fences and hedgerows, and, in some cases, the substitution of tile drains for open ditches. This is an example of a comparatively simple engineering improvement which is fundamental to the entire program for improved agriculture and soil conservation in the Southeastern States.

It has been somewhat surprising to notice the effect of buildings upon the farming program in the Central Western States. In this area agricultural authorities have demonstrated that, in general, the most prosperous farms are those having the highest density of livestock per acre. Our investigations have so far confirmed these findings.

It is obvious that without adequate farm buildings for the protection of the animals and for storing feed for livestock, the farmer can not develop a livestock enterprise. Without buildings for livestock and feed storage a farmer must necessarily turn to the production of cash crops which must be sold approximately as soon as harvested. This type of agriculture is not only less remunerative than livestock farming but it is a hard system as regards the preservation of soil fertility. As a matter of fact, almost all of the farming systems in the Central West are built around the buildings rather than around the machinery, power, or specialized crops. Although no detailed studies have been made of farms in the North Atlantic States, it is evident that most of the farms are amply equipped with buildings. It is true that many of them are out of date and not adapted to modern needs but, judging from trends developed by our work in other States, it would seem likely that the most efficient development of New England farms would include a complete use of the farm buildings.

With reference to power and machinery, it is of course entirely possible to build a farming program around power and machinery. In fact, that is what the farmer without buildings must do. In areas where land is cheap and particularly in one-crop regions such as the wheat areas of the Northwest, farms may be organized to fit the available capacity of the equipment to be used. In a settled community where land is expensive and where adjustments between abutting landowners are not easily made and where a variety of crops can be produced, it is evident that the machine must be fitted to the farm rather than the farm to the machinery. A few years ago in returning from a trip to the Pacific Coast, I stopped in the Paloose Valley of eastern Washington and there saw combine harvesters cutting and threshing wheat. The machines were large and each was pulled by 35 head of horses, the outfit giving an impression of tremendous size and power. Shortly thereafter in Massachusetts, for the first time in my life, I saw wheat being cut with a cradle. On first thought, the contrast between the two methods of harvesting wheat leads one to believe that the New Englander was wasting time in producing wheat since he did not have the latest harvesting equipment, but further reflection brings the thought that each of the two operators was using the equipment best suited for the conditions under which he was working. It is entirely possible that, considering the net income, the Massachusetts man had more money left at the end of the year than did the Paloose Valley farmer.

The economics of farm machinery from the farmers' standpoint is a complex thing. If a salesman were to attempt to sell a factory owner a piece of equipment which could be used only a week or two a year, he would not get to first base with his prospect, but with farm machinery the length of time of use annually may be immaterial. Unfortunately, the demands for farm labor and equipment are not uniform

over the cropping season but a number of major and minor peaks are usually found over a period of a few months. If an additional piece of equipment helps to ease the peak load, it may be an economical purchase although used only for a limited time. Here, again, the necessity of planning the equipment in connection with the farming program is demonstrated since much may be done in adjusting the kind and quantity of various crops to relieve peak loads. Advertisements in farm papers are often seen to the effect that "John Jones, by using our equipment, raised corn at a cost of 25 cents a bushel", and the inference is that the reader can also raise corn for 25 cents a bushel, provided he purchases the same equipment that John Jones used. This of course is wrong since the way in which the equipment fits into the entire farming program is the determining factor as to its value. The cost of the equipment is paid out of income from the entire farming operation and not from funds derived from one field or one crop. It has been brought out by our investigations that even though the cost of labor-saving machinery be high for an individual crop, if the labor saved can be used on the farm in caring for additional livestock or in the production of some specialized crop, the investment in the machinery will be justified by the net returns from the farm business as a whole.

So far, we have studied 20 farms in Georgia in five widely different areas of the State. The most prosperous of all these farms during the year in which the surveys were made was a mountain farm, mostly rough, stony, steep land with some bottom land subject to overflow along the creek, and with a total of 30 acres in cultivation. No one could be criticised for classifying this farm as submarginal, but due to the labor and equipment put on that land by the owner he had a net cash income aside from the family living produced on the farm of $3,000 which exceeded the earnings of all of the Georgia farms studied that year, and there are included in the study some large farms well adapted for general agriculture. Another farm, in Virginia, was so hilly and rough and so badly cut up by steep hillsides and rocky streams that it appears that the farmer is working under great disadvantages. Nevertheless, this farm has for many generations produced a living for from 3 to 5 families every year. We have other examples of prosperous farms which have been developed on poor soils or under conditions of poor natural drainage which are supporting and for years past have supported farm families. This does not mean necessarily that there is no such thing as submarginal land, but our studies tend to show that the fertility of the soil is not the most important factor in determining the profitableness of any farm. So far the results seem to show that it is the labor and equipment, including buildings and machinery, which are put on the land which determine its income value. These are the engineering elements of the farm business and it would appear that the importance of their effect upon the farm business has been underestimated in planning for better agriculture and more prosperous farms.